Concerning the general results of our journey and observations, from a scientific point of view, it is as yet a little early to speak, but we at least obtained some extremely valuable comparisons between the Libyan desert and other arid regions with which we are familiar, as well as a most interesting insight into some of the conditions which are peculiar to this region alone.

STUDIES ON CLIMATE AND CROPS

4. CORN CROPS IN THE UNITED STATES

BY

HENRYK ARCTOWSKI

The following figures, expressing in bushels the corn crop for the year 1906,* show plainly how much more important the culture of maize is in the United States than in any other country:

United States	2,927,416,000
Europe	609,614,000
South America	198,988,000
Africa	37,889,000
Australia	8,608,000

It is difficult to realize the quantity of grain 2,927,416,000 bushels represents.

C. P. Hartley writes† that: "If the corn crop of the United States for 1906 had been placed in wagons, fifty bushels per load, and allowing twenty feet of space for each wagon and team, the train of corn would have reached nine times around the world at the equator."

A verification of this statement, prompted by curiosity, gave me 8.8 times around the equator.

Another quotation and we will have an idea of the commercial value of the maize crop harvested in the United States. The Hon. James Wilson, Secretary of Agriculture, in his report for 1909 says:

"The most striking fact in the world's agriculture is the value of the corn crop of 1909 in this country. It is about $1,720,000,000. It nearly equals the value of the clothing and personal adornment of 76,000,000 people, according to the census of 1910. The gold and silver coin and bullion of the United States are not of greater value. This corn came up from the soil and out from the air in 120 days—$14,000,000 a day for one crop, nearly enough for two Dreadnoughts daily, for peace or war."‡

The following diagram (Fig. 1) shows the average yield of corn per acre for the years 1891 to 1909. We see that in 1901 there

* Yearbook of the Department of Agriculture for 1908, p. 597. Washington, 1909.
† Cyclopedia of American Agriculture, Edited by L. H. Baily. v. 2, p. 403. New York, 1907.
‡ Annual Report of the Dept. of Agric. for the year ended June 30, 1909. p. 10. Washington, 1910.

were only 16.7 bushels per acre harvested, while in 1906 there were 30.3. To make it plainer, I transcribe the figures of corn production for these years. They are: 1906, 2,927,416,091; 1901, 1,522,-519,891. The difference, 1,404,896,200, nearly equals the entire crop of 1901. This difference gives a good idea of the range of variations occurring.

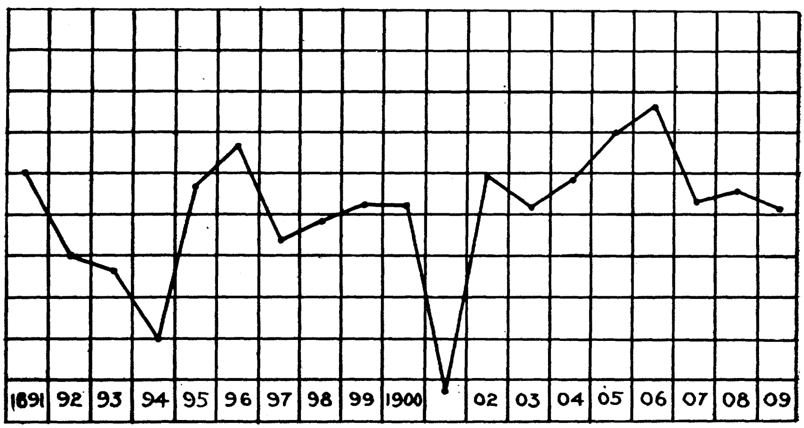

FIG. 1.

It is in the "corn belt" comprising the States of Iowa, Ohio, Indiana, Illinois and portions of Missouri, Kansas and Nebraska that the cultivation of maize is concentrated. Texas and Oklahoma, however, produce also great quantities of corn. In 1908 the corn acreage was as follows:

Illinois, 9,450,000; Iowa, 9,068,000; Texas, 7,854,000; Missouri, 7,542,000; Nebraska, 7,621,000; Kansas, 7,100,000.

More than a million acres were also given to maize culture in each of the following states: Pennsylvania, Virginia, North and South Carolina, Georgia, Ohio, Indiana, Michigan, Wisconsin, Minnesota, South Dakota, Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Oklahoma and Arkansas.*

One of the maps of the Census Atlas gives the distribution of corn production for 1900.† Notwithstanding the fact that this map expresses the distribution of the amounts of crop for one particular year,—and may therefore differ materially from one which could be drawn by using averages of a certain number of years,—it is still very interesting to compare it with the rainfall map.‡

This comparison suggests a search for the connections which may

* Agricultural Statistics, 1908. *Yearbook of Agric. 1908, p. 599.*
† *Statistical Atlas of the United States 1900. Plate No. 154.*
‡ *U. S. Geol. Surv. Water Supply Paper 234. 1909.*

exist between the corn crops and the variations of rainfall. Moreover, in a paper published in 1903, J. W. Smith* has shown that the corn crops depend very greatly on the rainfall of the months of June and July. The production of corn in the United States depends, therefore, entirely on the variations of rainfall in the "corn belt," or the central portion of North America.

In this paper I shall study geographically the corn crop statistics for the years 1891 to 1909. The figures in Tables 1 and 2, which follow have been calculated from the data given in a paper of Charles C. Clark† and the Yearbooks of the Department of Agriculture.

TABLE I. 1891–1900.

	MEAN	*1891*	*1892*	*1893*	*1894*	*1895*	*1896*	*1897*	*1898*	*1899*	*1900*
	Bush. p. acre:										
Maine	37.1	+0.4	-1.6	-6.8	+2.8	+4.9	-0.1	-0.1	+2.9	-1.1	-1.1
New Hampshire	37.3	-1.5	+0.5	-5.6	-3.0	+2.9	+4.7	-3.3	+3.7	+1.7	-0.3
Vermont	38.9	-1.7	-0.9	-6.5	+1.9	+6.7	+2.1	-3.9	+4.1	-2.9	+1.1
Massachusetts	38.0	+1.5	+0.7	-4.5	-3.5	+5.9	+5.0	-5.5	+2.0	-2.0	0.
Rhode Island	31.7	+2.8	+1.7	-7.3	-0.3	-0.8	+2.3	-0.7	+2.3	-0.7	+0.3
Connecticut	35.1	+0.9	-0.6	-6.9	-4.1	+2.8	+2.9	-3.6	+1.9	+3.9	+2.9
New York	31.9	-0.1	+1.1	-2.4	-3.7	+3.7	+2.1	-0.9	+1.1	-0.9	+0.1
New Jersey	33.1	+1.1	-1.5	-7.2	0.	-0.1	-0.1	-1.6	+3.9	+5.9	-0.1
Pennsylvania	32.4	+0.9	-1.9	-7.9	-0.4	+1.1	+7.6	+3.6	+4.6	-0.4	-7.4
Delaware	23.0	-1.0	-4.3	+1.6	-1.0	-2.0	-1.0	+6.0	+2.0	-1.0	+1.0
Maryland	27.4	-1.9	-6.8	-3.2	-4.5	-0.6	+4.6	+5.6	+3.6	+4.6	-1.4
Virginia	18.9	+0.8	-3.6	0.	+0.2	-0.3	+2.6	-0.9	+3.1	+1.1	-2.9
West Virginia	25.1	+2.2	-2.6	-3.4	-6.6	-0.9	+4.9	-0.6	+3.9	+0.9	+1.9
North Carolina	12.8	+1.3	-2.6	-0.5	+0.6	+1.7	-0.8	+0.2	+1.2	+0.2	-0.8
South Carolina	9.8	+2.0	+0.9	-1.9	+1.6	+1.5	-0.6	-0.6	+0.4	-0.6	-2.6
Georgia	11.0	+1.2	+0.2	+0.1	+0.7	+2.0	0.	0.	-2.0	-1.0	-1.0
Florida	9.6	+1.4	-0.6	+0.1	+0.5	+1.6	+0.4	-1.6	-0.6	+0.4	-1.6
Ohio	32.7	-0.7	-3.3	-8.9	-6.4	-0.1	+8.3	-0.2	+4.3	+3.3	+4.3
Indiana	32.6	+0.7	-3.3	-7.9	-3.7	+0.2	+2.4	-2.6	+3.4	+5.4	+5.4
Illinois	32.8	+0.7	-6.6	-7.1	-4.0	+4.6	+7.7	-0.3	-2.8	+3.2	+4.2
Michigan	30.0	-0.5	-5.0	-6.3	-6.8	+3.8	+8.0	+1.5	+4.0	-5.0	+6.0
Wisconsin	31.6	-4.9	-4.3	-1.8	-10.9	+0.2	+5.4	+1.4	+3.4	+3.4	+8.4
Minnesota	28.6	-2.1	-1.6	-0.3	-10.2	+2.6	+1.9	-2.6	+3.4	+4.4	+4.4
Iowa	32.1	+4.6	-3.8	+1.8	-17.1	+3.0	+6.9	-3.1	+2.9	-1.1	+5.9
Missouri	27.6	+2.3	+0.1	+0.3	-5.6	+8.4	-0.6	-1.6	-1.6	-1.6	+0.4
North Dakota	21.0	-3.0	+0.4	-0.3	-1.8	+0.3	+14.0	-4.0	-2.0	+2.0	-5.0
South Dakota	21.5	+1.0	+0.8	+2.2	-17.3	-10.4	+4.5	+2.5	+6.5	+4.5	+5.5
Nebraska	25.3	+9.9	+2.9	-0.1	-19.3	-9.2	+12.2	+4.7	-4.3	+2.7	+0.7
Kansas	21.6	+5.1	+2.9	-0.3	-10.4	+2.7	+6.4	-3.6	-5.6	+5.4	-2.6
Kentucky	26.0	+4.0	-2.7	-2.5	-3.0	+5.2	+2.0	-3.0	+5.0	-4.0	0.
Tennessee	22.1	+0.6	-1.8	-0.8	-0.2	+2.9	+0.9	-1.1	+3.9	-2.1	-2.1
Alabama	12.8	-0.1	-0.6	-1.3	+0.9	+3.1	-0.3	-0.8	+2.2	-0.8	-1.8
Mississippi	14.8	+0.4	-1.1	-1.7	+2.4	+1.0	-1.3	-0.3	+3.2	+1.2	+3.8
Louisiana	16.4	+0.9	-1.6	-2.2	-0.2	+1.7	-3.4	+0.6	+1.6	+1.6	+0.6
Texas	19.3	+0.2	+2.1	-1.7	-0.3	+7.1	-9.8	-0.8	+5.7	-1.3	-1.3
Arkansas	18.4	+2.8	-0.9	-2.2	+0.8	+3.1	-4.4	-2.4	+1.6	+1.6	+0.6
Montana	(23.8)	.....	-4.4	+3.7	+8.9	+1.2	+2.2	-5.8	+4.2	-0.8	-8.8
Wyoming	(22.6)	.....	-4.1	-4.1	+7.4	+4.9	+2.4	-10.6	-6.6	-0.6	+11.4
Colorado	19.0	+2.5	+3.3	-2.5	+0.7	+1.7	-3.0	0.	-1.0	-2.0	0.
New Mexico	21.6	-3.3	-1.6	-3.7	-2.5	+5.6	-5.6	+5.4	-0.6	-1.6	+0.4
Utah	21.1	-2.1	-3.0	+0.4	+3.3	-0.8	+3.9	+0.9	-0.1	-1.1	-1.1
Washington	(18.2)	.....	-0.2	+3.1	+2.6	-1.1	-4.2	-0.2	-6.2	+4.8	+1.8
Oregon	24.1	+2.9	-2.6	+0.6	+1.3	+2.3	-2.1	+0.9	-0.1	-2.1	-1.1
California	30.2	+4.3	+0.1	+6.9	-10.9	+4.3	+6.8	+1.3	-4.2	-3.2	-5.2

* Relation of precipitation to yield of corn. *Yearbook U. S. Dept. of Agric.*, *1903*.

† Corn crops of the United States, 1866–1906. *Bur. of Stat.*—Bull. 56. 1907.

TABLE II. 1900–1909.

	MEAN	*1900*	*1901*	*1902*	*1903*	*1904*	*1905*	*1906*	*1907*	*1908*	*1909*
	Bush. p. acre:										
Maine	35.4	+0.6	+4.0	-13.7	-5.2	+4.3	-1.1	+1.6	+1.6	+5.1	+2.6
New Hampshire	33.1	+3.9	+5.4	-9.8	-12.1	-5.8	+3.9	+4.4	+1.9	+5.9	+2.0
Vermont	34.5	+5.5	+5.5	-12.7	-11.1	+1.4	+0.2	+1.0	+1.5	+5.8	+2.5
Massachusetts	36.1	+1.9	+4.4	-4.8	-12.1	-0.1	+1.4	+3.6	-0.1	+4.3	+1.9
Rhode Island	32.9	-0.9	-0.8	-4.5	-2.8	+1.2	-0.4	+0.2	-1.7	+9.9	+0.3
Connecticut	36.8	+1.2	+2.2	-5.3	-14.4	+2.1	+5 9	+3.2	-3.8	+4.5	+4.2
New York	31.0	+1.0	+2.0	-6.0	-6.0	-3.7	+0.5	+3.9	-4.0	+7.8	+5.0
New Jersey	34.1	-1.1	+2.8	+0.4	-10.1	+3.9	+1.7	+2.2	-2.6	+3.9	-1.4
Pennsylvania	34.4	-9.4	+0.6	+1.7	-3.2	-0.4	+4.5	+5.8	-1.9	+5.1	-2.4
Delaware	29.1	-5.1	+0.9	-1.1	-1.6	+1.3	+1.3	+0.9	-1.6	-2.9	-1.9
Maryland	32.9	-6.9	+1.3	-0.5	-4.2	+0.5	+4.0	+2.1	+1.3	+3.7	-1.5
Virginia	22.7	-6.7	-0.5	-0.7	+0.1	+0.6	+0.7	+1.6	+2.3	+3.3	+0.5
West Virginia	27.5	-0.5	-4.5	-1.0	-4.9	-2.2	+2.3	+2.8	+0.5	+3.7	+3.9
North Carolina	14.8	-2.8	-2.8	-0.9	-0.1	+0.4	-0.9	+0.5	+1.7	+3.2	+2.0
South Carolina	11.6	-4.6	-4.7	-1.2	-1.3	+0.8	-0.7	+0.6	+3.5	+2.5	+5.1
Georgia	11.5	-1.5	-1.5	-2.5	+0.2	+0.4	-0.5	+0.5	+1.5	+1.0	+2.4
Florida	10.2	-2.2	-1.2	-1.6	-0.3	+0.5	-0.1	+0.8	+1.1	+0.3	+2.4
Ohio	35.6	+1.4	-9.5	+2.4	-6.0	-3.1	+2.2	+7.0	-1.0	+2.9	+3.9
Indiana	34.7	+3.3	-14.9	+3.2	-1.5	-3.2	+6.0	+4.9	+1.3	-4.4	+5.3
Illinois	34.5	+2.5	-13.1	+4.2	-2.3	+2.0	+5.3	+1.6	+1.5	-2.9	+1.4
Michigan	32.7	+3.3	+1.8	-6.3	+0.8	-4.1	+1.3	+4.3	-2.6	-0.9	+2.7
Wisconsin	33.2	+6.8	-5.8	-5.0	-3.9	-3.5	+4.4	+8.0	-1.2	+0.5	-0.2
Minnesota	29.4	+3.6	-3.1	-6.6	-1.1	-2.5	+3.1	+4.2	-2.4	-0.4	+5.4
Iowa	32.3	+5.7	-7.3	-0.3	-4.3	+0.3	+2.5	+7.2	-2.8	-0.6	-0.8
Missouri	28.6	-0.6	-18.5	+10.4	+3.8	-2.4	+5.2	+3.7	+2.4	-1.6	-2.2
North Dakota	23.4	-7.4	-0.8	-4.0	+1.8	-2.2	+4.1	+4.4	-3.4	+0.4	+7.6
South Dakota	27.4	-0.4	-6.4	-8.5	-0.2	+0.7	+4.4	+6.1	-1.9	+2.3	+4.3
Nebraska	27.4	-1.4	-13.3	+4.9	-1.4	+5.4	+5.4	+6.7	-3.4	-0.4	-2.6
Kansas	22.4	-3.4	-14.6	+7.5	+3.2	-1.5	+5.3	+6.5	-0.3	-0.4	-2.5
Kentucky	26.7	-0.7	-11.1	+0.3	-0.1	+0.2	0.	+6.3	+1.5	-1.5	+2.3
Tennessee	23.0	-3.0	-8.8	-1.1	+0.5	+2.0	+1.6	+5.1	+3.0	+1.8	-1.0
Alabama	13.5	-2.5	-2.6	-5.1	+1.3	+1.5	+1.3	+2.5	+2.0	+1.2	0.
Mississippi	15.2	-4.2	-4.3	-3.7	+3.2	+3.9	-0.9	+3.3	+1.8	+2.1	-0.7
Louisiana	17.5	-0.5	-3.8	-5.0	+3.1	+2.4	-3.8	-0.3	0.	+2.3	+5 5
Texas	19.0	-1.0	-7.4	-10.9	+5.2	+3.6	+2.3	+3.5	+2.0	+6.7	-4.0
Oklahoma	24.2	+1.8	-14.7	+1.2	+1.3	+6.0	+0.2	+9.1	+0.2	+0.6	-7.2
Arkansas	18.7	+0.3	-10.6	+2.6	+2.2	+2.9	-1.4	+4.9	-1.5	+1.5	-0.7
Montana	23.2	-8.2	+1.8	-1.2	+0.9	-1.0	-3.8	+0.2	-0.7	+0.2	+11.8
Wyoming	28.0	+6.0	+11.5	-8.2	-8.6	+4.5	-1.1	-1.0	-3.0	0.	0.
Colorado	21.2	-2.2	-4.1	-4.7	-1.4	-0.7	+2.6	+6.7	+2.3	-1.0	+3.0
New Mexico	26.4	-4.4	+5.2	-4.4	-2.4	-3.7	-1.1	+3.0	+2.6	+0.6	+4.9
Arizona	26.5	-5.5	-8.5	-6.3	-4.1	-2.7	+0.5	+3.0	+11.0	+6.7	+5.6
Utah	26.9	-6.9	-7.5	-6.8	-5.5	+6.3	+9.3	+5.1	-1.4	+2.5	+4.5
Idaho	29.5	+8.5	-6.5	-4.8	+5.0	-0.2	-2.3	-1.2	+0.5	-0.5	+1.1
Washington	23.8	-3.8	-6.3	-0.8	-0.7	+0.9	+0.4	+1.4	+3.2	+1.7	+4.0
Oregon	25.8	-2.8	-5.0	-2.4	0.	+3.0	-2.8	+1.8	+1.7	+2.0	+4.9
California	31.3	-6.3	-0.3	-0.8	-0.6	-2.7	+0.7	+3.6	+2 7	+0.7	+3.5

The first table gives for each State, in bushels per acre, the average of the years 1891 to 1900 and the annual departures. The positive figures express bushels per acre above the average and the negative figures those below. The second table gives the departures for 1900 to 1909 from the means of these ten years. In this way the year 1900 is repeated in both tables, and, therefore, comparing the corresponding departures, we have a criterion of the relative value of the figures employed to draw the maps.

One sees directly that in the majority of cases the departures (for 1900) are less positive or more negative in the second table than in the first. This is due to the fact that on the average the harvests

were better during the years 1900 to 1909 than they were from 1891 to 1900, a fact due, in all likelihood, to the progress of agriculture and irrigation.

I shall now take up the examination of the maps, which have been drawn in exactly the same manner as those of the wheat crops published previously.*

First, I shall take into consideration the decade 1891 to 1900, for which I reproduce the maps of 1894, 1896, 1898 and 1900.

These maps show that precisely in the same way as for the maps of temperature departures,† atmospheric pressure departures‡ and wheat crops, the areas of deficit and surplus are very extensive, but always less extensive than the entire area of the United States. One of the States, particularly favored, forms a positive center, around which less positive figures are grouped. In other places, or for another year, we observe one or more negative centers and again all around a decrease in negativity.

A striking fact is the lack of symmetry of the center of greatest departure for the positive as well as the negative areas. The map of the year 1898 furnishes an excellent example, the departure +6.5 of South Dakota contrasting with the figure —6.6 of Wyoming. In this as in other cases,—just as for the maps of wheat crops, temperature or atmospheric pressure departures,—the disposition of the positive and negative areas gives to the maps the appearance of representing the effect of a dynamical phenomenon proceeding by waves. This is clearly shown by the tendency of the areas, surrounded by equi-departure curves, to assume elongated forms.

Sometimes two or more distinct centers are connected, forming a wave, and, in other cases, such waves following different directions intersect each other. Peculiarities of one map may be found again on the map of the following year, but altered and displaced. It is, therefore, most probable that the variations of harvests depend on dynamical phenomena proceeding by waves. But if these statements lead to the conclusion that the climatic changes which affect the crops are dynamical, we must also admit that the phenomenon is too complicated to attempt its study by a simple comparison of maps drawn from annual means.

The comparison of the above maps with those giving the distribution of the surplus and deficit of wheat crops, for the same years, proves that the climatic changes, peculiar to these years, reacted very

* *Bull. Amer. Geogr. Soc., vol. 42, p. 481.*

† Arctowski: L'enchaînement des variations climatiques. Bruxelles, 1909.

‡ Arctowski: Variations in the distributions of atmospheric pressure in North America. *Bull. Am. Geogr. Soc., vol. 42, p. 270.*

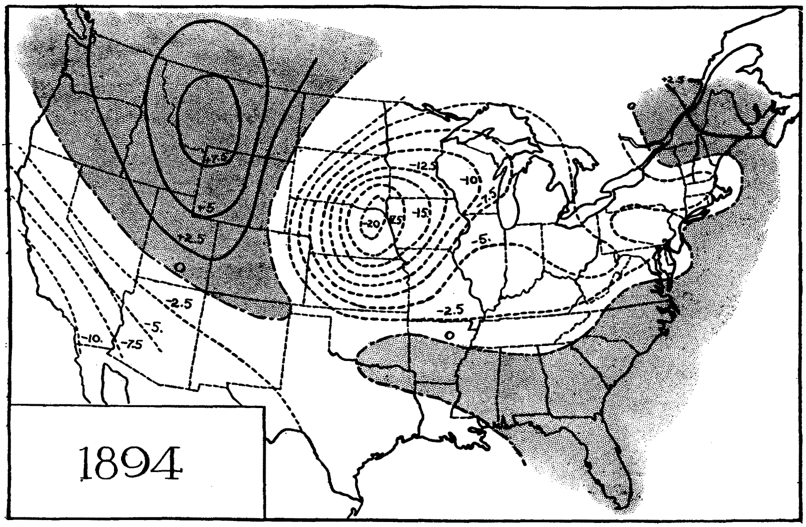

FIG. 2.

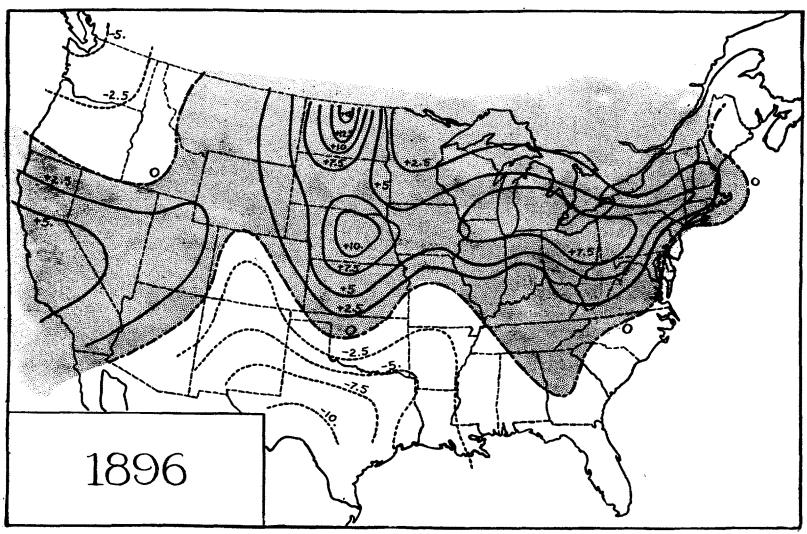

FIG. 3.

differently on corn and wheat.* The same may be said about the maps of temperature and atmospheric pressure departures, a com-

* Concerning the crops of maize, cotton and wheat, I transcribe the following statement from a paper of A. Piatt Andrews: "Among these three crops may occur every conceivable combination of success and failure. The crops of the Southern States may be abundant when those of the Middle West are poor . . . You may find a small wheat crop, as in 1885 or in 1896, combined in each case with record breaking corn crop or *vice versa*. . ." *Quart. Journ. of Economics*, *1906*, *p. 333*.

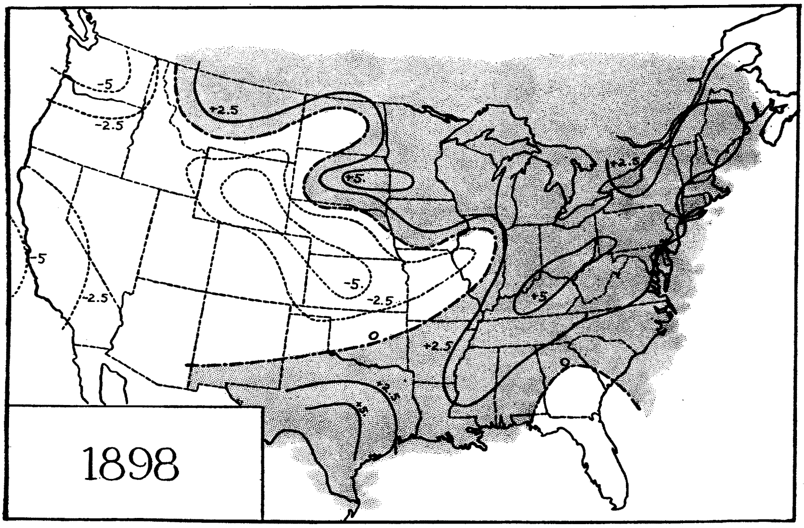

FIG. 4.

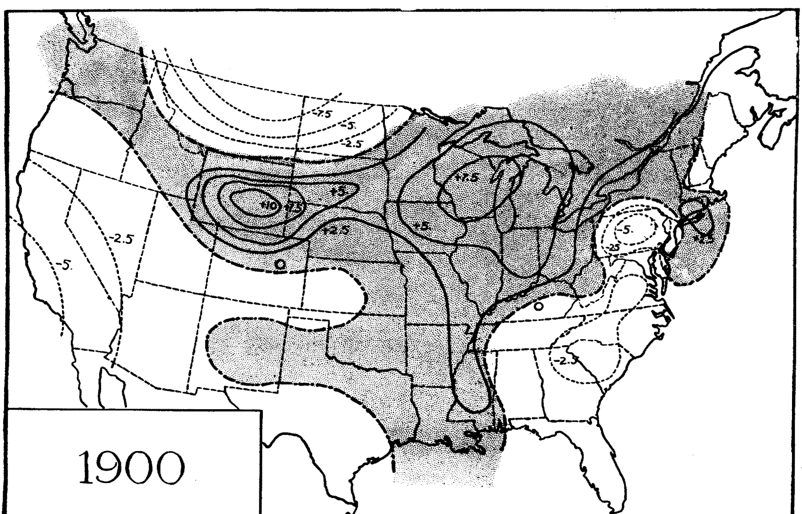

FIG. 5.

parison of which with the preceding maps shows that the apparent correlations are only suggestive,—but just enough so to warrant a deeper investigation by new researches.

It is the dynamical problem of the propagation of climatical variations which ought to be solved. As a starting point to this re-

search,—a research for which I am at present gathering meteorological data, from all parts of the world, for the years 1900 to 1909,—I reproduce below the maps of the corn crop departures for these years. It is the cause of the particularities of these maps that I should like to understand. I will therefore describe them such as I see them.

To simplify the description I shall hereafter call those years, characterized by positive departures, *fat years*, and those for which the corn crops were below the average *lean years*. I also call *"fat"* and *"lean"* the positive and negative areas. It will also be necessary to speak of the center of a fat or of a lean wave and of the axis of such a wave.

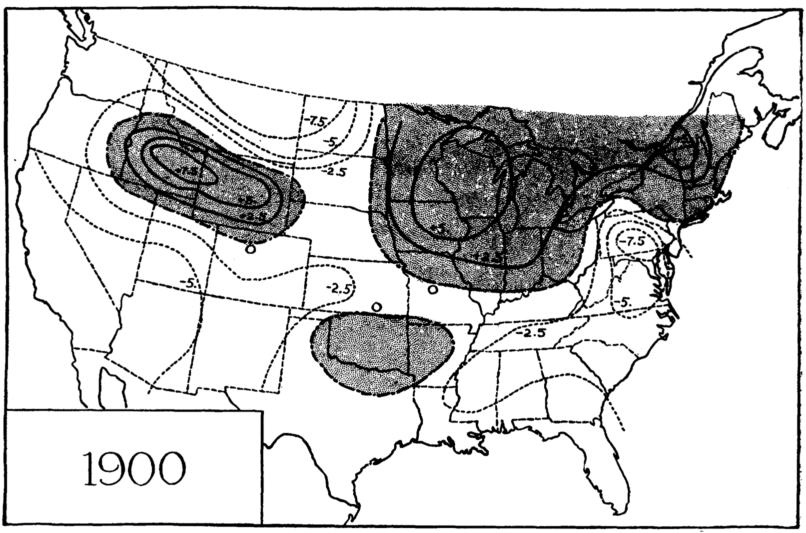

FIG. 6.

Let us now examine the maps. The map of 1900 differs from that reproduced above because of the increase in the average outputs shown in almost all of the States. A comparison of the means of tables 1 and 2 shows this increase to be particularly noticeable in the States of Delaware, Maryland, South Dakota, Wyoming, New Mexico, Utah and Washington, while it is only in the New England States and Texas that the averages of 1900 to 1909 are less than those for the years 1891 to 1900.

The distribution of the equi-departure curves, however, is obviously the same, which proves that we can draw conclusions from the appearance of the maps, that we can take into consideration even the

details they present. Now, if we compare the map of 1901 with that of the preceding year we can explain it as follows: The lean extending over the Atlantic States, in the form of a wave, and whose center, with a value of —9.4, was in Pennsylvania, moved westward, developed itself considerably and became much more pronounced, the central value being —18.5.

It is truly astonishing to see how the geographical distribution of the figures agrees with the conception of a center of crop deficit. From the figure —18.5 observed in Missouri we note the figures —7.3, —3.1 toward the north, —14.9, —9.5, +0.6, +2.0, +5.5 toward the North-East. In a southeastern direction we have —8.8,

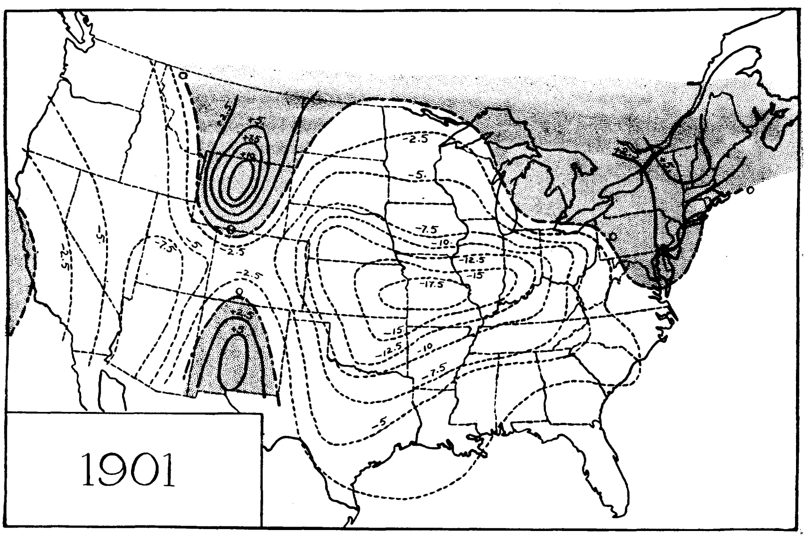

FIG. 7.

—4.7, South: —10.6, —3.8, and also toward the South-West, the West and the North-West of Missouri the figures are so distributed that the equi-departure curves, far from being hypothetical, express just as plainly the resultant of a series of variable phenomena as isobars or isotherms of a meteorological map may do. And, as in the case of meteorological maps, the displacement of a center brings about the displacement of other centers, just as if they were driven ahead or carried along, we see here that the fats have been pushed away by the broadening out of the lean areas, from Wisconsin into Wyoming and from Oklahoma into New Mexico.

The positive wave of 1900, together with the negative saddle be-

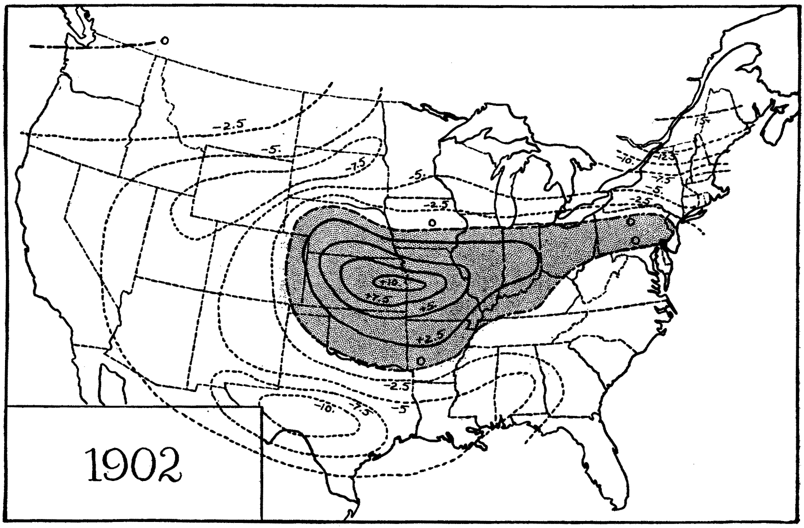

FIG. 8.

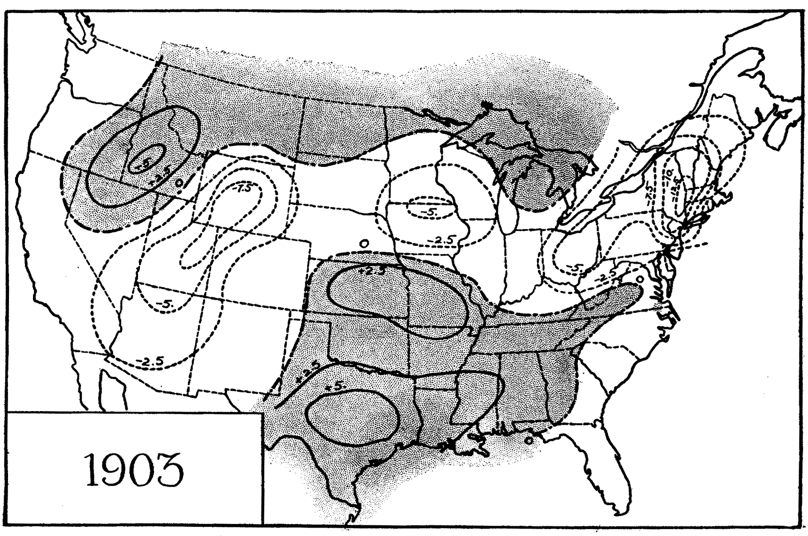

FIG. 9.

tween the two centers, has remained and the whole simply moved toward the West.

The values in the North-East, however, remained positive. In 1902, this fat seems to have been driven, in its turn, by a lean coming from the North whose departure —13.7, observed in Maine, is suffi-

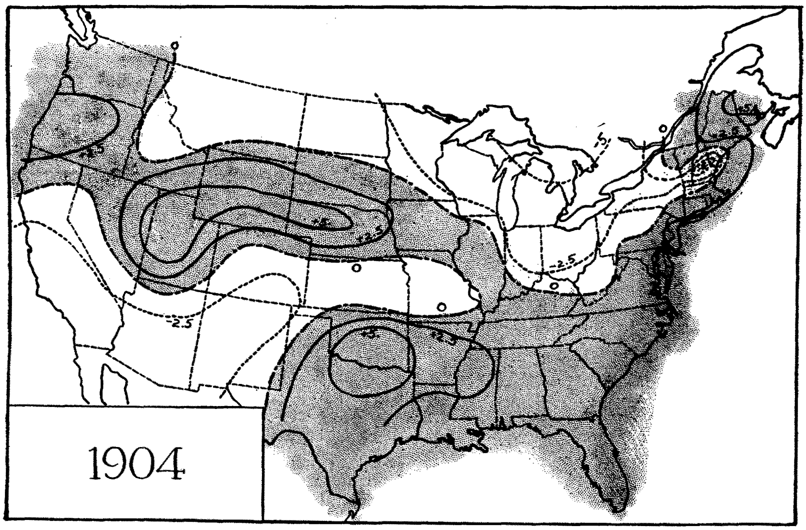

FIG. 10.

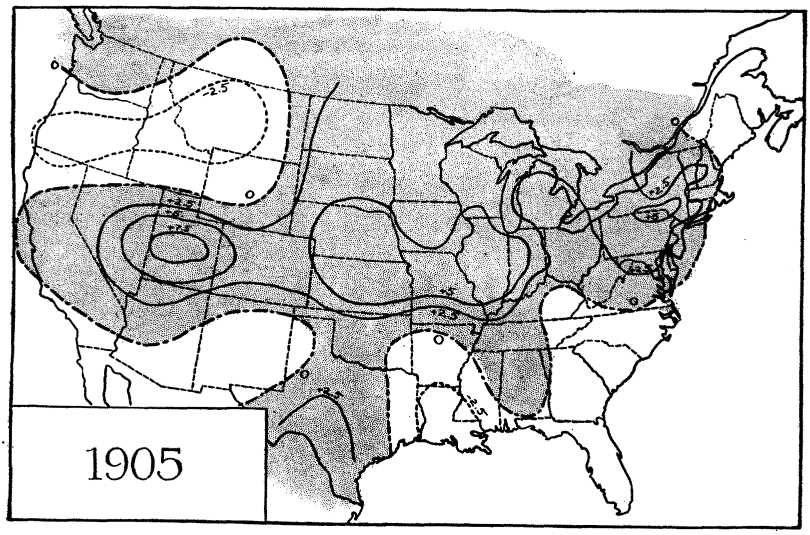

FIG. 11.

ciently characteristic. The fat has a peculiar oblong shape and its center has taken the place of the lean center of the preceding year. Moreover, the lean of 1901, pushed toward the West by this invading fat, took the shape of a horse shoe with two negative centers, one North and the other South of the fat. In 1903 it is a displace-

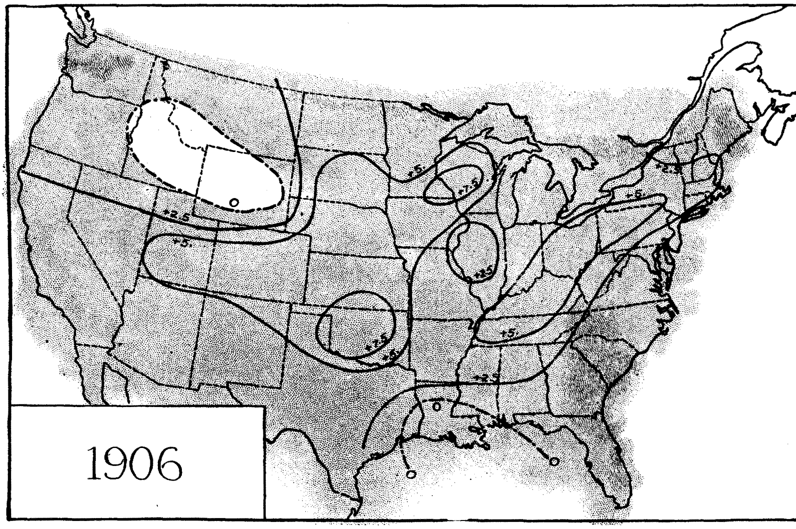

FIG. 12.

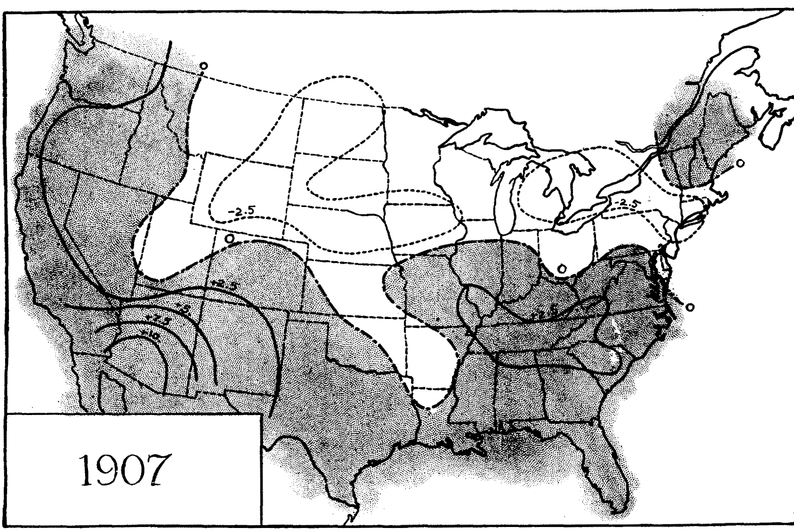

FIG. 13

ment from the North toward the South that we observe. This is seen by the position of the Northeastern lean, which moved further south. The center of the fat has moved from Missouri to Texas, and, if it is so, the lean wave extending from the Northeastern States across Pennsylvania, Ohio, Iowa, to beyond the Rocky Moun-

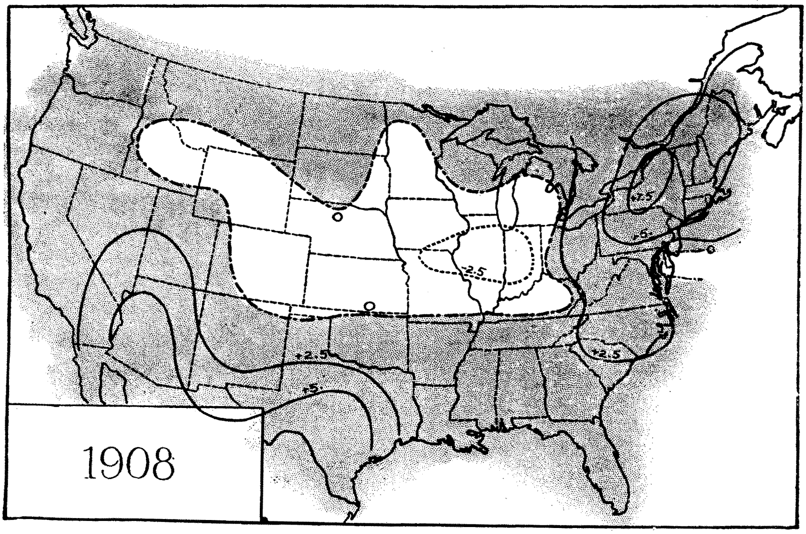

FIG. 14.

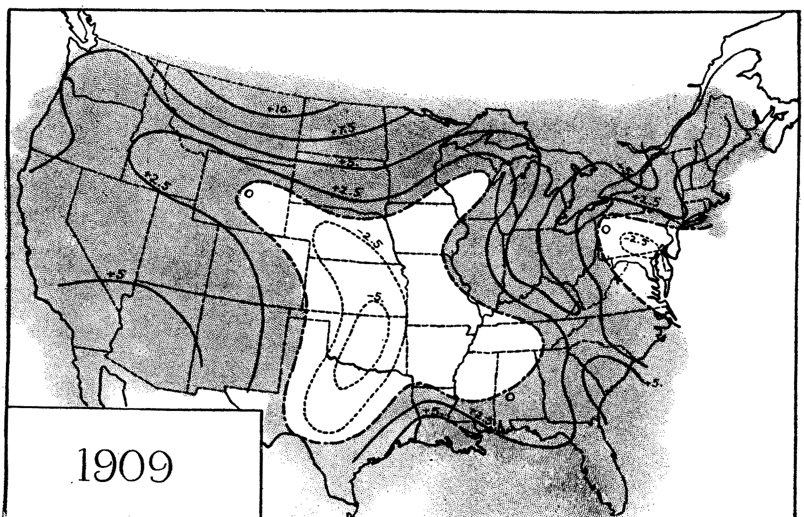

FIG. 15.

tains, where it turns South, is nothing else than the northern branch of the great horseshoe shaped wave surrounding the fat center of the previous year.

The map of 1904 (although very different from that of 1903) suggests a double displacement, from North to South and from East

to West. The same may be said about the map of 1905, that year being distinguished by a fat wave crossing the continent from the Atlantic to the Pacific. If it is again a question of displacement, we may imagine that the lean of the Great Lake Region moved into Montana, Idaho and Oregon, while that which covered California, Arizona and New Mexico, with an extension going as far as Missouri, likewise moved in the same or at least in a south-westerly direction, and that it is the northeastern fat which is now observed in the central part of the continent.

The map of 1906 is that of an extraordinary year, for everywhere, except in Idaho, Wyoming and Louisiana, the departures are positive; but even there the conditions are improved. The lean of the North-West is reduced, likewise that of Louisiana, and the fat simply spread out.

In 1907 the disposition of the equi-departure curves forces us to admit that the lean, which spread over the lake region and into Montana, Utah and Kansas thrust aside to the South-East and South-West the fat centers of 1906: that of Ohio into Tennessee and those of Wisconsin and Oklahoma over into Arizona.

The map of 1908 is not less interesting. The lean remained, but decreased in size and importance. A fat coming from the North-East reduced the eastern portion of the lean. Positive values observed in Wisconsin, the Dakotas and Montana surround it completely in the north. And, the fat remaining in the South-West prevented a downward or retreating movement of the lean towards the South or West. Lastly, the map of 1909 seems to give evidence that the preceding reasonings are not simply speculations.

The differences between the positive and negative values are increased and, at the same time, there is such an analogy in the distribution of the equi-departure curves, that one must admit that the lean of 1909 is the lean of 1908, more concentrated, having been pushed by fat waves from the North and from the South-East against stationary fats in the South and South-West.

The center of the lean moved from Indiana into Oklahoma, the negativity increasing at the same time from —4.4 to —7.2. The lean in Delaware, on the map of 1908, spread out into New Jersey, Pennsylvania and Maryland. The positive wave which extended from Maine across New York into North Carolina goes now from Indiana to South Carolina.

If we take all the maps into consideration now, and try to classify them according to their general appearance, we may make the following distinctions:

Years of nearly normal conditions, years nearly uniformly good or bad and, finally, years for which the yield of crops is particularly different from one region to another. There are different ways of expressing by figures the state of agitation or anomaly which the maps express graphically. We may note the differences of the highest and lowest departures of the fats and leans, that way taking into account the maximum amplitude of the waves. We may also take the mean value of the departures at all the centers above or below the normal.

Finally, we may add also, for each year, the values for all the departures noted in the different States, without taking into consideration the sign (+ or —) of the departures. For example, in 1901 the greatest departures are —18.5 and +11.5, which according to the first method gives 30.0. By the third method the figure 274.2 is obtained.

Evidently, these figures have no real signification and can only serve as a numerical method of comparing the maps. However, the result to which one is led by making these simple additions is really curious.

The following diagram, which expresses these figures graphically, indeed demonstrates the fact that the degree of perturbation of the maize crop does not change at random from one year to another. We see increasing values from 1891 to 1894 and then a more or less progressive decrease. In 1901 we notice an abrupt increase followed anew by a gradual diminution until 1904, or even 1907, if we consider the value of 1906 as abnormal. But the interesting point is that 1893 was a year of maximum sun-spot frequency, 1901 the year of a minimum and that the following maximum was observed in 1905 or 1907.

Therefore, we see a coincidence of maxima (1894), or an inversion (1901 and 1907). This is just what has been frequently observed in the study of the correlations of meteorological phenomena with sun spot frequency, and this is precisely what so singularly complicates the discussion of the question of solar influence.

To leave no doubt about the fact the anomalies of crops reflect the anomalies of solar radiation, under the influence of climatical variations, I reproduce here below the figures giving the amplitudes of the extreme hyper and hypo-pressure waves, for 1891 to 1899, as they were published in the first of these papers.*

48, 66, 67, 71, 66, 62, 58, 54, 49.

* *Bull. Amer. Geogr. Soc., vol. 42, p. 281.*

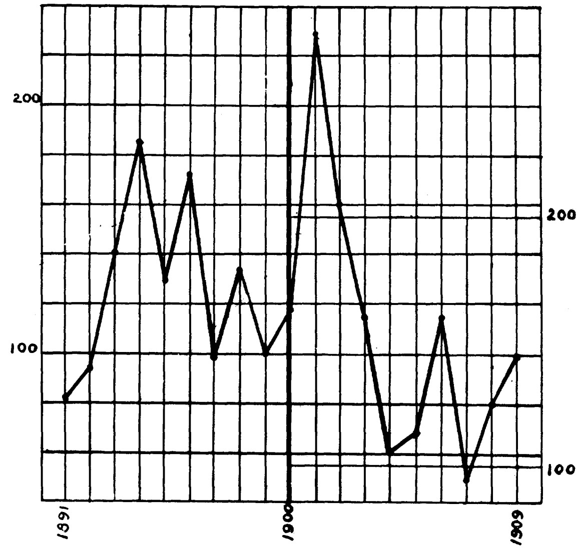

FIG. 16.

The corresponding figures of the corn crops are:

13.2, 9.9, 15.8, 28.9, 18.8, 23.6, 16.6, 13.1, 10.4.

To come back, finally, to the question of the influence of rainfall upon the crops, I will cite the following fragment from a discussion by Cleveland Abbe of a paper by H. C. Russell on the variations of atmospheric precipitation in Australia:*

"Now, this periodicity, or rather the irregular succession of good seasons and bad seasons, is a fact recognized in every portion of the world. We also have enough data to show that in most cases a drought in one portion of the globe is accompanied by rains in other portions, and the regions of excess and deficiency of rain move over the surface of the globe month by month and year by year."

To my knowledge this last fact has not yet been proven. At present it is but a simple assertion. Considering the close correlation which seems to exist in the United States between the rainfall, during the summer months, and the crop of maize, and considering the enormous commercial importance of this cereal, I will study more in detail the question of rainfall and water resources as soon as circumstances will permit.

New York, January 21, 1911.

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* E. B. Garriott: Long-range weather forecasts. *Weather Bureau*, Bull. no. 35, p. 30. Washington, 1904.